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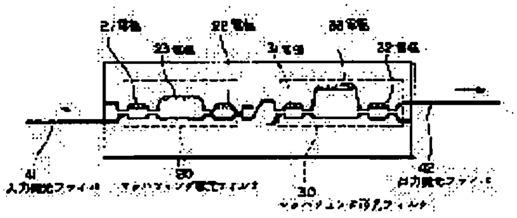
(54) OPTICAL GAIN EQUALIZING CIRCUIT

(57)Abstract:

PURPOSE: To obtain an optical gain equalizing circuit whereby a sufficient transmission characteristic is secured even when the number of stage in an optical amplifier is large and even when the umbalance of the gain is large.

CONSTITUTION: First and second Much-Zehnder-shape filters 20 and 30 with mutually different change cycles on the wave-length (or optical frequency) axis of transmissivity are continuously connected. Thus, the nonuniformity of a gain wave-length (or optical frequency) characteristic which cannot be flattened by the first Much-Zehnder-shape optical filter 20 can be flattened by the second Much-Zehnder-shape optical filter 30 with the change cycle on the wave-length (or optical frequency) axis of transmissivity, being different from that of the above first Much-Zehnder-shape optical filter 20.



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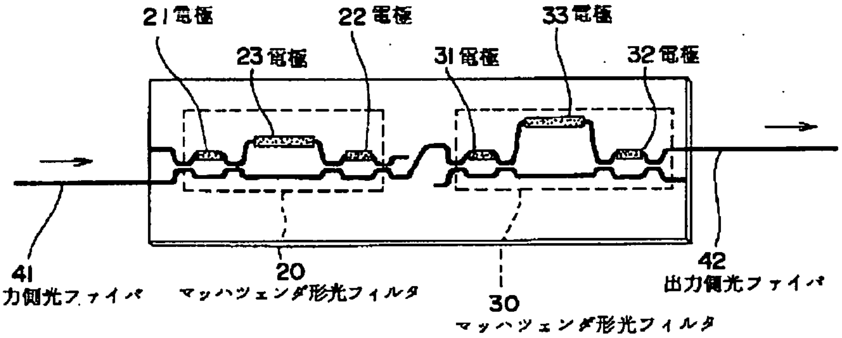
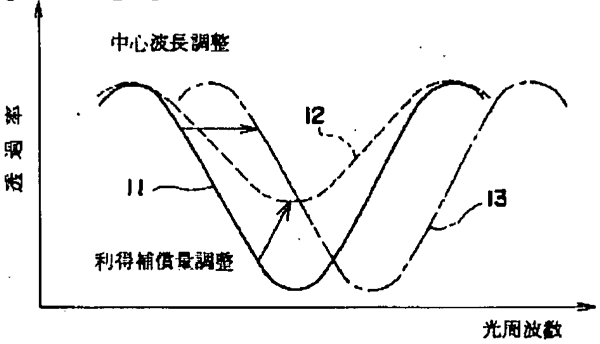
DRAWINGS

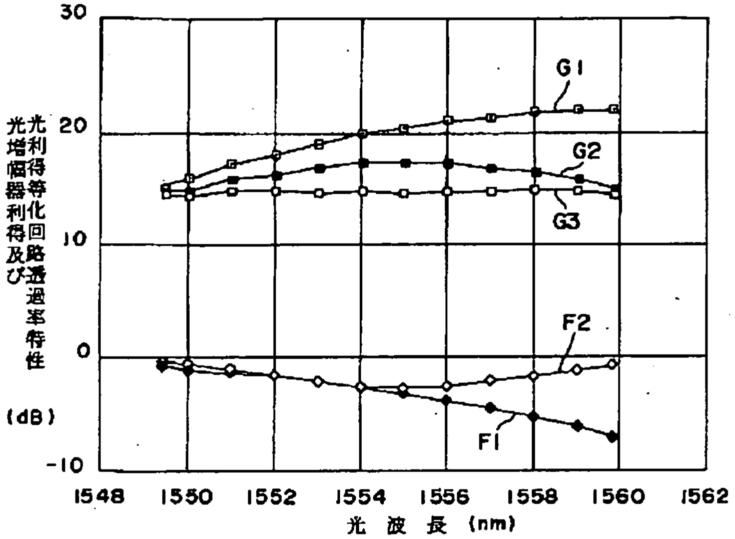
[Drawing 1]


21電極
22電極
33電極
23電極
31電極
32電極
41
入力側光ファイバ
20
マッハツェンダ形光フィルタ
30
マッハツェンダ形光フィルタ
42
出力側光ファイバ

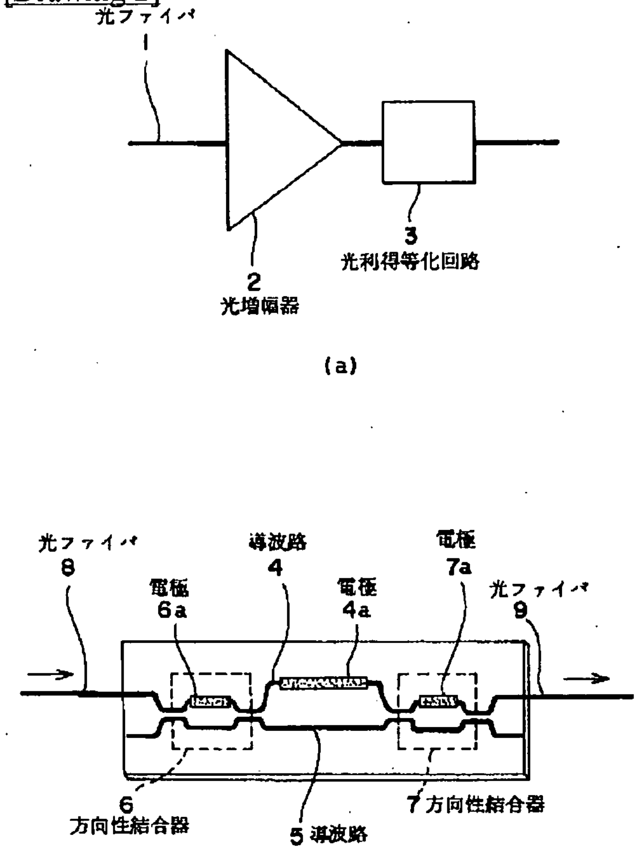
[Drawing 3]



[Drawing 6]



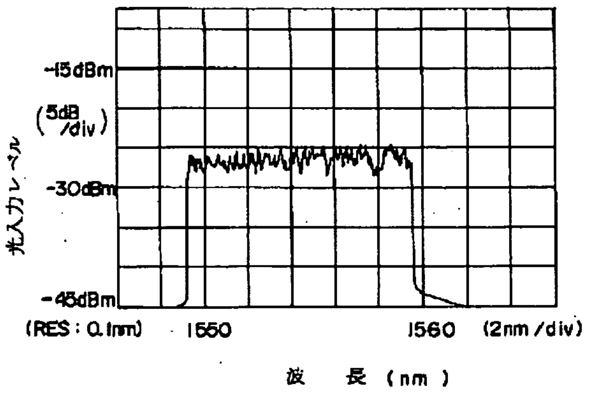
[Drawing 2]


光ファイバ
1
2
光増幅器
3
光利得等化回路
光ファイバ
8
導波路
4
電極
6a
電極
4a
電極
7a
光ファイバ
9
6
方向性結合器
5 導波路
7 方向性結合器

(a)

(b)

[Drawing 5]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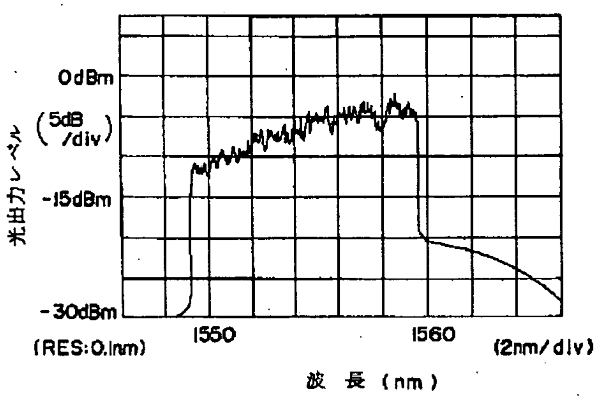
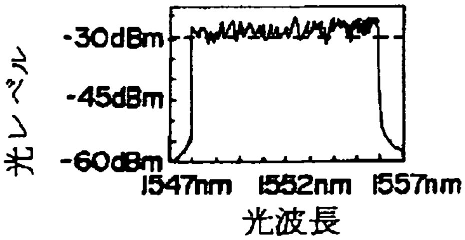
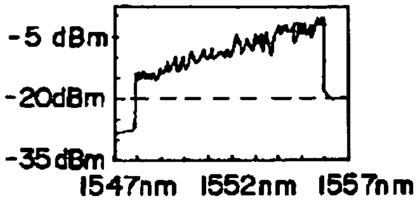
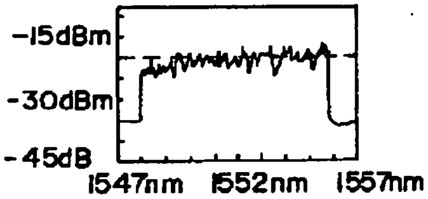
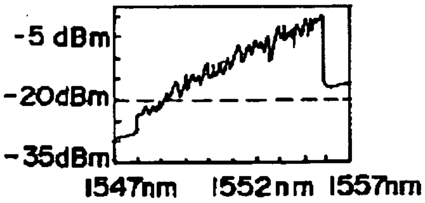
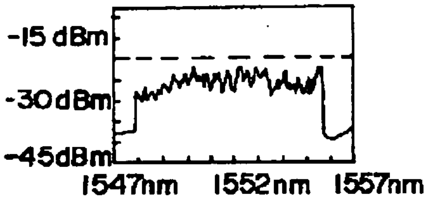
(5dB/div)
光入力レベル
-30dBm
-45dBm
(RES : 0.1nm)
1550
1560
(2nm/div)
波 長 (nm)

(a)


0dBm
(5dB/div)
光出力レベル
-15dBm
-30dBm
(RES:0.1nm)
1550
1560
(2nm/div)
波 長 (nm)

(b)

[Drawing 4]

	光利得等化回路無し	光利得等化回路有り
光増幅器入力		
第3光増幅器出力		
第6光増幅器出力		

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the Mitsutoshi profit equalizing circuit used for a light wave length (or optical frequency) multiplex transmission system.
[0002]
[Description of the Prior Art] A light wave length (or optical frequency) multiplex transmission system is a method which multiplexes and transmits two or more signal light from which the wavelength (or optical frequency) on which information rode differs mutually to one optical fiber. If the optical amplifier which amplifies the multiplexed signal light collectively to said method is applied, the transceiver level difference of a transmission system will be improved and expansion of the transmission distance in a long-distance transmission system and increase of the distribution number in an information distribution transmission system will be attained.
[0003] By the way, generally, when the gain of an optical amplifier amplifies collectively the signal light by which wavelength multiplexing was carried out from it not being fixed with wavelength, the optical level after magnification changes with wavelength, and the difference of this optical level accumulates it especially with the signal light which penetrated two or more optical amplifiers. Consequently, when separating spectrally the signal light multiplexed in the receiving end and receiving, optical level changed with wavelength, the increment in a channel to channel cross talk and degradation of an SN ratio arose in the channel especially with optical low level, and there was a problem that receiving sensibility deteriorated.
[0004] As an approach of compensating the wavelength dependency of the gain of the optical amplifier mentioned above The former, The good alignment Mach TSUENDA form optical filter which has an adjustable permeability property is made into the Mitsutoshi profit equalizing circuit. It uses. A light wave length multiple-signal output there is an example which carried out flattening (it Inoue(s) reference 1:K --) T. Kominato, and H.Toba, and "Tunable gain equalization using a Mach-Zehnder optical filter in multi-stage fiber amplifiers"IEEE Photon.Technol.Lett., vol.3, No.8, pp.718-720, 1991 or reference 2:H.Toba, KNakanishi, and KOda, KInoue, and T.Kominato, and "A 100-channel optical FDM in-line amplifier system employing tunable gain equalizers"ECOC'92 Collected-works pp.113 -116 reference.
[0005] Drawing 2 shows the Mitsutoshi profit equalizing circuit carried by the reference mentioned above. Drawing 2 (a) The connection mode of an optical amplifier and the Mitsutoshi profit equalizing circuit is shown, and it has become as [carry out / by the Mitsutoshi profit equalizing circuit 3 / flattening of the imbalance of the optical level of the light wave length multiple signal which was inputted into the optical amplifier 2, was amplified and was outputted to it from the optical fiber 1].
[0006] Drawing 2 (b) The detailed configuration of the Mitsutoshi profit equalizing circuit is shown, and it has the configuration of the Mach TSUENDA form optical filter which connected the input side and output side of two waveguides 4 and 5 from which die length differs with directional couplers 6 and 7, respectively. The directional couplers 6 and 7 of said input side and an output side have the structure of the Mach-Zehnder interferometer of a symmetry mold, and can change the joint effectiveness by adjusting the bias current to the electrodes 6a and 7a for each phase adjustment. As electrodes 6a and 7a, Cr heater can be used, for example and it is possible to adjust a phase by the thermooptic effect produced by passing a current to these electrodes 6a and 7a.
[0007] drawing 2 (b) Case where set and the transmission property to the optical fiber 9 of an output side removes

superfluous loss of waveguide loss, fiber waveguide connection loss, etc. from the optical fiber 8 of an input side T**1-A-cos2 {(lambda-lambdao) pi/deltalambda} .... (1) ** -- it is expressed. However, lambda is operating wavelength and lambdao here. The main wavelength from which the permeability of a Mitsutoshi Moto profit equalizing circuit serves as the minimum value, and A are the real numbers which fill 0< A<=1. This permeability property has the periodicity of periodic deltalambda.

[0008] Drawing 3 shows the permeability property of said Mitsutoshi profit equalizing circuit. Here, it is the above (1) by adjusting the bias current of the electrodes 6a and 7a for phase adjustment. It is possible to adjust the amount of gain compensation of the original permeability property which A of a formula could be changed and was shown as the continuous line 11, as a broken line 12 shows. Moreover, it is the above (1) by adjusting the bias current of electrode 4a. lambdao of a formula It is possible to adjust the main wavelength of a permeability property, as it can be made to change and an alternate long and short dash line 13 shows.

[0009] Drawing 4 shows the situation of the gain identification carried by said reference 2. Here, the spectrum at the time of amplifying the signal light of 100 channels multiplexed at intervals of [of 0.08nm (optical frequency spacing of 10GHz)] the wavelength which occupies 1556nm from 1548nm of light wave length with the erbium addition optical amplifier of the aluminum coaddition by which multistage connection was made is shown.

[0010] The input spectrum of an optical amplifier and the output spectrum of the 3rd step and the 6th step of optical amplifier when not using the Mitsutoshi profit equalizing circuit are shown in the left-hand side of drawing 4 . When not using the Mitsutoshi profit equalizing circuit, it turns out that the imbalance of the optical level of a light wave length multiple signal increases with the number of stages of an optical amplifier. Moreover, the output spectrum of this optical gain equalizing circuit at the time of inserting in the right-hand side of drawing 4 the Mitsutoshi profit equalizing circuit shown in drawing 2 for three steps of every optical amplifiers is shown. When the Mitsutoshi profit equalizing circuit is used, it turns out that the imbalance of the optical level of a light wave length multiple signal can be compensated to some extent.

[0011]

[Problem(s) to be Solved by the Invention] However, although the spectrum corresponding to the 3rd step of optical amplifier output shows the almost flat property if the spectrum with the Mitsutoshi profit equalizing circuit shown in the right-hand side of drawing 4 is seen in a detail, as for the spectrum corresponding to the 6th step of optical amplifier output, it turns out that it is the convex property in which surface smoothness deteriorated and near the core of a spectrum rose. Even if the degradation inclination of this surface smoothness increased further with the increment in the number of stages of an optical amplifier and used the Mitsutoshi profit equalizing circuit mentioned above, it had the problem that a transmission characteristic deteriorated.

[0012] In view of said conventional trouble, this invention aims at offering the Mitsutoshi profit equalizing circuit which can secure a good transmission characteristic, when there are many number of stageses of an optical amplifier, or even when the imbalance of the gain is large.

[0013]

[Means for Solving the Problem] It sets to the Mitsutoshi profit equalizing circuit which carries out flattening of the gain wavelength (or optical frequency) property of an optical amplifier that wavelength (or optical frequency) amplifies collectively the signal light by which mutually different plurality was multiplexed in order to attain said purpose in this invention, and the Mitsutoshi profit equalizing circuit which comes to carry out cascade connection of at least two Mach TSUENDA form optical filters with which the change periods on the wavelength (or optical frequency) shaft of permeability differ mutually is proposed.

[0014]

[Function] A Mach TSUENDA form optical filter has the permeability property of changing in the shape of a sine wave on a wavelength (or optical frequency) shaft. By the way, it is clear from the fourier expansion-into-series method for the wave of arbitration to be formed by superimposing two or more sine waves which have a mutually different period. Then, it is theoretically possible to realize the permeability property of arbitration by carrying out cascade connection of two or more Mach TSUENDA form optical filters with which the change periods on the wavelength (or optical frequency) shaft of permeability differ mutually (in addition, the number of stages of the Mach TSUENDA form optical filter which carries out cascade connection will be determined according to the surface smoothness of the optical amplifier output demanded.).

[0015] According to the Mitsutoshi profit equalizing circuit of this invention, flattening of the heterogeneity of the gain wavelength (or optical frequency) property which was not able to finish carrying out flattening is carried out in the 1st step in the Mitsutoshi profit equalizing circuit which used one step of conventional Mach TSUENDA form optical filter with the Mach TSUENDA form optical filter after the 2nd step whose change periods on the wavelength (or optical frequency) shaft of permeability differ.

[0016]

[Example] Hereafter, this invention is explained to a detail using an example. Drawing 1 shows one example of the Mitsutoshi profit equalizing circuit of this invention, and, for 20, as for the 2nd Mach TSUENDA form optical filter and 41, the 1st Mach TSUENDA form optical filter and 30 are [an input-side optical fiber and 42] output side optical fibers among drawing.

[0017] The change periods on the wavelength (or optical frequency) shaft of permeability differ mutually, and the Mach TSUENDA form optical filters 20 and 30 are connected to two-step concatenation. The configuration of each Mach TSUENDA form optical filters 20 and 30 is fundamentally [as what was shown in drawing 2] the same. It is for the electrodes 31 and 32 in the Mach TSUENDA form optical filter 30 to adjust the amount of gain compensation of a permeability property to the electrode 21 and 22 lists in the Mach TSUENDA form optical filter 20. Moreover, it is for the electrode 33 in the Mach TSUENDA form optical filter 30 to adjust the main wavelength of each permeability property to the electrode 23 list in the Mach TSUENDA form optical filter 20.

[0018] A concrete operation of this example is explained using observation data. Drawing 5 is optical frequency spacing of 10GHz which shows an example of the actual measurement of the I/O spectrum of an optical amplifier, and has the band of 1559.8 nm from 1549.5 nm wavelength here. The spectrum at the time of amplifying the multiplexed signal light of 128 channels with an aluminum coadditive erbium addition optical amplifier is shown. According to said observation result, in this operating wavelength band, the gain of an optical amplifier is as large as the channel of long wavelength, and, moreover, it turns out that the inclination saturated as the rate of increase of gain becomes long wavelength is shown.

[0019] Drawing 6 shows the situation of the gain identification by this circuit, and shows the gain spectrum of the optical amplifier read in drawing 5 with a curve G1. On the other hand, if a periodic deltalambda=25nm thing is chosen as 1st Mach TSUENDA form optical filter 20 and this is adjusted to main wavelength lambdao =1546.570nm and A= 1, the permeability property will serve as a curve shown by F1 in drawing 6 . Consequently, although the gain spectrum of the optical amplifier compensated with the 1st Mach TSUENDA form optical filter 20 serves as a curve shown by G2 in drawing 6 and the wavelength dependency of the gain after the right improves, it becomes a convex wavelength property and the residual gain deflection of 2.7 dB arises.

[0020] Here, if a periodic deltalambda=7.5nm thing is further chosen as 2nd Mach TSUENDA form optical filter 30 and this is adjusted to main wavelength lambdao =1555nm and A= 0.46, the permeability property will serve as a curve shown by F2 in drawing 6 . Consequently, the gain spectrum of the optical amplifier compensated with the 1st Mach TSUENDA form optical filter 20 and the 2nd Mach TSUENDA form optical filter 30 serves as a curve shown by G3 in drawing 6 , and residual gain deflection is oppressed by 0.7 dB.

[0021] Thus, by using two kinds of Mach TSUENDA form optical filters with which the change periods on the wavelength (or optical frequency) shaft of permeability differ, it becomes possible to make the wavelength dependency of gain very flat.

[0022] Although cascade connection of another Mach TSUENDA form optical filter was carried out immediately after the Mach TSUENDA form optical filter in this example, it is satisfactory even if it detaches and stations both. Moreover, although the Mach TSUENDA form optical filter has been arranged to the output stage of an optical amplifier in this example, you may arrange to an input stage.

[0023] Moreover, although two-step cascade connection of the Mach TSUENDA form optical filter with which change periods differ was carried out and it was used in this example, it is also still more possible plurality and to carry out cascade connection and to carry out flattening of the gain in the Mach TSUENDA form optical filter with which change periods differ depending on the wavelength dependency of the gain of an optical amplifier.

[0024]

[Effect of the Invention] As explained above, according to this invention, the wavelength dependency of the gain of an optical amplifier Irrespective of the number of stages of an optical amplifier, or the magnitude of the imbalance, it can compensate appropriately. Can make very flat optical level of a light wave length multiple signal, and it follows. In a light wave length (or optical frequency) multiplex transmission system, the number of stages of an optical amplifier can be increased as compared with the former, and increase of a distribution number is attained in expansion of a transmission distance, and an information distribution transmission system in a long-distance transmission system. Moreover, it cannot be overemphasized that it is possible to be able to compensate by the Mitsutoshi Moto profit equalizing circuit also about the wavelength dependency of the permeability property of not only an optical amplifier but other optical circuits in the transmission line which exists between transceiver circuits, and to carry out flattening of the wavelength property.

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CLAIMS

[Claim(s)]
[Claim 1] The Mitsutoshi profit equalizing circuit characterized by setting to the Mitsutoshi profit equalizing circuit which carries out flattening of the gain wavelength property of an optical amplifier that wavelength amplifies collectively the signal light by which mutually different plurality was multiplexed, and coming to carry out cascade connection of at least two Mach TSUENDA form optical filters with which the change periods on the wavelength shaft of permeability differ mutually.

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